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PROVINCE OF MANITOBA

DEPARTMENT OF MINES



AND NATURAL RESOURCES

WATER CONTROL AND CONSERVATION BRANCH

HYDROMETEOROLOGICAL NETWORKS

FOR

OPERATION OF THE RED RIVER FLOODWAY

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Winnipeg, Manitoba.  
August, 1970.

Prepared by:  
Planning Division.

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## HYDROMETEOROLOGICAL NETWORKS

FOR

### OPERATION OF THE RED RIVER FLOODWAY

#### A. Precipitation

Precipitation data in the Canadian portion of the Red River and Assiniboine River Basins are compiled by the Water Resources Branch of the Manitoba Department of Mines and Natural Resources from the network of climatological and meteorological stations maintained by the Meteorological Branch, Canada Department of Transport. Precipitation data from the portion of Red River Basin in the U.S.A. is compiled from the climatological station network maintained by the Environmental Science Service Administration, U.S. Department of Commerce. The stations in these networks used in connection with operation of the Floodway are shown in Tables I and II.

#### B. Soil Moisture

Soil moisture throughout the Canadian portion of the Red River Basin at freeze-up each year is determined by the Manitoba Water Resources Branch. These surveys began in 1955. The locations of soil moisture survey stations in Red River Basin, excluding the Assiniboine River Basin are shown in Table III. The Soil Moisture network in the Assiniboine River Basin is shown in Table IV.

#### C. Snow Survey

Snow surveys are conducted by the Manitoba Water Resources Branch in mid-February and mid-March throughout Manitoba and portions of Saskatchewan. These surveys began in 1952. The locations of the

snow survey stations in the Red River Basin are shown in Table V.

Table VI lists the snow survey stations in the Assiniboine River Basin.

In addition to the snow surveys undertaken by the Manitoba Water Resources Branch, data are obtained from the snow survey network maintained by the Environmental Science Service Administration of the United States Department of Commerce (E.S.S.A.), on the snow cover in the U.S. portion of the Red River Basin. Snow survey stations in the E.S.S.A. network from which data are obtained are listed in Table VII.

#### D. Hydrometric

A hydrometric network is co-operatively maintained in the Canadian portion of the Red River Basin by the Water Survey of Canada and the Manitoba Water Resources Branch.

The hydrometric stations from which up to date data are collected and compiled by the Water Resources Branch in the Canadian portion of the Red River Basin insofar as operation of the Red River Floodway is concerned are shown in Tables VIII and IX.

In the United States portion of the Red River Basin a comprehensive hydrometric network is maintained by the United States Geological Survey. The stations in this network from which data are compiled by the Manitoba Water Resources Branch are shown in Table X.

In addition to the above information, more intensive information on the above-named parameters is obtained from four small watersheds within the Red River Basin which are used as index areas to provide early indications of the rate and amount of runoff from the winter snow pack. These index areas are described in detail in the following section.

FLOOD FORECASTING PROCEDURE  
RED AND ASSINIBOINE RIVERS

Preliminary Forecasts (issued late February and late March).

1. Soil Moisture Survey

Soil moisture is determined at the stations listed in Tables I and II early in November. Although this information has not been used quantitatively in the forecast system to date, it does provide a qualitative assessment of the moisture conditions of the watershed near the time of freeze-up.

2. Snow Surveys

Snow surveys are made throughout the Canadian portion of the Red River Basin and the Assiniboine Basin in mid-February and mid-March. The results of these snow surveys are not used directly in the multiple correlation model developed for forecasting runoff. However, the information is critically examined and estimates of potential runoff are made using a range of runoff coefficients and these results are compared to the forecast derived from the runoff precipitation model. The snow survey results also give an indication of the over-winter depletion of the snow pack which can be quite substantial under certain meteorological conditions.

3. Precipitation

An index of antecedent soil moisture conditions for the Assiniboine Basin is obtained from the precipitation stations listed in Table II. The method used is as outlined in "Report - Conservation and Flood Control - Assiniboine River" prepared by the P.F.R.A. in 1952.

Winter precipitation for both the Red and Assiniboine River Basins is obtained from stations listed in Tables I and II. The

method used to estimate the effective snow pack for the Assiniboine River Basin is as outlined in the above report whereas the method used for the Red River Basin is as outlined in "Report on Investigation into Measures for the Reduction of the Flood Hazard in the Greater Winnipeg Area" prepared by the Red River Basin Investigation in 1953 (R.R.B.I.).

#### 4. Streamflow

For the Red River Basin winter streamflow at Emerson measured by the Water Survey of Canada, is used as an index of antecedent soil moisture conditions as outlined in the aforementioned Red River Basin Investigation report. The measured streamflow at this station is corrected by making adjustments for upstream storage and releases from information supplied by the U.S. Corps of Engineers.

#### 5. Preparation of Forecasts

##### (a) Red River

Using the above parameters combined with estimates of snowfall for the remainder of the winter along with estimates for spring rainfall and temperatures during the melting period, forecasts of runoff volume at Emerson are prepared using the graphical model in the R.R.B.I. report. Using the 84 hour unit hydrograph developed from data presented in this report along with an estimate of the base flow a peak flow at Emerson is obtained. A peak-stage relationship, which has been modified from that in the R.R.B.I. report to take cognizance of rating curve changes since 1950, is used to estimate the peak stage at Winnipeg that would result without flood control works. The effect of flood control works is computed and a forecast is made for the peak stage at Winnipeg.

(b) Assiniboine River

Preliminary forecasts of spring peak flows on the Assiniboine River are made at the same time as those for the Red River. The method outlined in the P.F.R.A. 1952 report is generally followed. The river basin is divided into five sub-basins: Millwood, Brandon, Rivers, Tantallon and Wawanesa. For each sub-basin a ground water index is developed from antecedent precipitation during the period June 1st to November 5th. The total effective precipitation for the winter and spring is then estimated according to the procedures developed in the 1952 P.F.R.A. report. An estimated melting index together with the ground water index and the total effective precipitation, is used to derive the most probable runoff coefficient. This runoff coefficient is used to compute the runoff based on the snowpack. Estimates of peak flow at Brandon, Portage la Prairie and Headingly are computed by means of unit-hydrographs and channel routing.

OPERATION FORECASTS  
(WHEN RUNOFF HAS COMMENCED)

Red River

1. U.S. Data

E.S.S.A. forecasts for Emerson are generally used although modifications may be made after interpretation of hydrometric data from the stations shown in Table VIII. During floods the Water Resources Branch has an employee stationed at Fargo to collect data.

2. Index Areas

A very useful tool in runoff forecasting from snow melt is that of index areas. This is particularly true in large basins having prolonged runoff characteristics such as the Red and Assiniboine Basins. The runoff from small tributaries drainage basins is complete prior to runoff being well advanced over the whole basin. By measuring the available snowpack along with the precipitation during the runoff period and comparing the available moisture to the measured runoff, the percentage runoff is determined. The runoff coefficient thus obtained can be applied over large areas and an appraisal can be made of the expected runoff and peak flows.

To provide an estimate of runoff coefficients in the Red River Basin four index areas are used: the South Branch of the Buffalo River at Sabin, Minn., the Tongue River at Akra, N.D., Dead Horse Creek at Morden, Man., and the Rosengart Coulee near Sarto, Manitoba. Detailed snow surveys are made on these areas just prior to runoff. These are followed by an intensive hydrometric program after runoff has commenced. Estimates of the runoff coefficient are made and corrected as runoff progresses. These runoff coefficients are applied to larger areas and estimates of peak flows at various points along



the Red River are made. The Tongue River and Rosengart Coulees have not proven as satisfactory as the South Branch of the Buffalo River and Dead Horse Creek and an attempt will be made to establish more satisfactory index areas in these vicinities.

### 3. Hydrometric Data

Hydrometric data are obtained at the stations shown in Table VIII. These data are used in updating and modifying forecast magnitude and date of peak flows on the Red River.

### 4. Canadian Tributary Runoff

An estimate of the tributary runoff hydrographs for those major streams downstream from Emerson is made using snow survey data and various runoff coefficients. Unit hydrographs shown in the R.R.B.I. report are used for the western tributaries, whereas unit hydrographs as revised by the Water Resources Branch are used for the eastern tributaries. As the runoff progresses and data as to the runoff situation becomes available, forecast tributary runoff is adjusted.

### 5. River Routing

Emerson flows, tributary flows and estimated ungauged flows are routed from Emerson to Ste. Agathe and from Ste. Agathe to Winnipeg. Routings are undertaken on a digital computer by the Muskingum method as developed by the Water Resources Branch. The flows thus derived are added to computed Assiniboine River flows to derive the total flow and associated stage at Winnipeg.

#### Assiniboine River

Hydrometric gauging stations for the Assiniboine River are listed in Table IX. The preliminary forecast issued in March is updated using hydrometric data as it arrives. Oak Creek near Stockton and

Conjuring Creek near Russell are closely observed as index areas as a check on melt rates and runoff coefficients.

Hydrometric data are assembled each day from the stations listed in Table IX, and runoff rates are modified daily on the basis of these data.

A river routing procedure to be used in the operational forecasting of the Assiniboine River flood flows is being developed at the present time.

TABLE I

Precipitation Stations - Red River Basin

U. S. Portion

Ada	Langdon
Adams	Larimore
Amenia	Lisbon
Angus	Litchville
Argyle	Mahnomen
Campbell	Mayville
Colgate	McHenry
Cooperstown	McLeod
Crockston	McVille
Detroit Lakes	Oklee
Elbow Lake	Ottertail
Enderlin	Park River
Fargo	Pelican Rapids
Fergus Falls	Pembina
Fosston	Petersburg
Forman	Red Lake Falls
Gonvick	Red Lake Ind. Ag.
Goodridge	Roseau
Grafton	Sharon
Grand Forks	Sheyenne
Hallock	Thief Lake Refuge
Hankinson	Thief River Falls
Harvey	Trail
Hawley	Valley City
Herman	Wahpeton
High Landing	Wheaton
Hillsboro	

Canada Portion

Altona	Morris (Exp. St.)
Boissevain	Ste. Genevieve
Emerson	Sprague
Graysville	Winnipeg
Morden (Exp. Farm)	

TABLE II

Precipitation Stations - Assiniboine River Basin

Birtle  
Bottineau  
Brandon  
Broadview  
Carlyle  
Caron  
Ceylon  
Chaplin  
Crosby  
Davidson  
Dauphin  
Dilke  
Estevan  
Francis  
Foam Lake  
Grenfell  
Hubbard  
Indian Head  
Kamsack  
Lumsden  
Melita  
Midale  
Minnedosa  
Minot  
Mohall  
Moose Jaw  
Ninette  
Pilger  
Portage la Prairie  
Regina  
Rivers  
Rugby  
Russell  
Semans  
Scuris  
Strasbourg  
Towner  
Tugaske  
Virden  
Waskada  
Whitewood  
Yellowgrass  
Yorkton

TABLE III

Soil Moisture Stations - Red River Basin in Manitoba.

<u>Station No.</u>	<u>Station Location</u>
R - I - 1	St. Norbert
R - I - 2	Fannystelle
R - I - 3	Rathwell
R - I - 4	Killarney
R - I - 5	Turtle Mountain
R - I - 6	Morden
R - I - 7	Lowe Farm
R - I - 8	Letellier
R - I - 9	La Riviere
R - II - 1	Ste. Anne
R - II - 2	Steinbach
R - II - 3	Domnion City
R - II - 4	Stuartburn

TABLE IV

Soil Moisture Stations - Assiniboine River Basin in Manitoba and Saskatchewan.

<u>Station No.</u>	<u>Station Location</u>
A - I - 1	Millwood
A - I - 2	Runnymede
A - I - 3	Yorkton
A - I - 4	Canora
A - I - 5	Theodore
A - II - 1	Broadview
A - II - 2	Lipton
A - II - 3	Regina
A - III - 1	Melita
A - III - 2	Carlyle
A - III - 3	Benson
A - III - 4	Estevan
A - III - 5	Weyburn
A - III - 6	Radville
A - IV - 1	Brandon
A - IV - 2	Shoal Lake
A - IV - 3	Virden
A - IV - 4	Moosomin
A - V - 1	Minnedosa
A - V - 2	Wasagamung
A - V I - 1	Portage la Prairie
A - VI - 2	Cypress River

TABLE V

Snow Survey Stations - Red River Basin in Manitoba

<u>Station No.</u>	<u>Station Location</u>
C - 1	Fannystelle
C - 2	Rathwell
C - 12	Turtle Mountain
C - 13	Killarney
C - 14	La Riviere
C - 15	La Riviere
C - 16	Morden
C - 17	Carman
C - 18	St. Norbert
D - 12	Gretna
D - 13	Morris
D - 1	Beausejour
D - 7	Ste. Anne
D - 8	Sandilands F.R.
D - 9	Vassar
D - 10	Stuartburn
D - 11	Dominion City
D - 14	St. Pierre

TABLE VI

Snow Survey Stations - Assiniboine River Basin in Saskatchewan and Manitoba

<u>Station No. 1</u>	<u>Station Location</u>
A - 15	Watson
A - 17	Wynyard
A - 18	Sheho
A - 19	Yorkton
B - 6	Russel
B - 7	Roblin
B - 8	Madge Lake S.
B - 9	Madge Lake N.
B - 10	Kamsack
B - 11	Canora
B - 12	Tall Pines, Porcupine F.R.
A - 9	Broadview
A - 10	Indian Head
A - 11	Regina
A - 12	Moose Jaw
A - 13	Penzance
A - 14	Watrous
A - 20	Church Bridge
A - 6	Kenton
A - 7	Varden
A - 8	Moosomin
B - 4	Shoal Lake
B - 5	Birtle
B - 3	Minnedosa
B - 26	Riding Mountain
B - 27	Wasagamung
A - 5	Rivers
C - 4	Wawanesa
C - 5	Souris
C - 6	Sinclair
C - 7	Carlyle
C - 8	Hume
C - 9	Estevan
C - 10	Oxbow
C - 11	Melita
A - 1	Portage la Prairie
A - 4	Brandon
C - 3	Cypress River



TABLE VII

Snow Survey Stations - Red River Basin in the United States.

Abercrombie  
Crookston  
Fargo  
Grand Forks  
High Landing  
Pembina  
Wahpeton  
Bald Hill  
White Rock Dam  
Park River  
Ada  
Argyle  
Cavaller  
Amenia  
Agassiz Refuge  
Campbell  
Chaffey  
Colgate  
Detroit Lakes  
Halstad  
Drayton  
Fosston  
Foreman  
Hallock  
Larimore  
Lisbon  
Mayville  
Mahnomon  
McLeod  
Thief River Falls  
Walhalla  
Valley City

TABLE VIII

Hydrometric Stations - Red River Basin in Canada

Red River

James Ave. Pumping Station  
South Perimeter Bridge  
Below Floodway Inlet  
Above Floodway Inlet  
St. Adolphe  
Ste. Agathe  
Morris  
St. Jean  
Letcher  
Emerson  
Aubigny

Red River Tributaries

Roseau River @ Dominion City  
Roseau River @ Gardenton  
Roseau River @ International Boundary  
Roseau River @ Langside Bridge  
Seine River Diversion @ PTH #59  
Seine River @ Prairie Grove  
Seine River @ PTH 59  
Prairie Grove Drain @ PTH 59  
Main Drain 4A @ Dominion City  
La Salle River E. 33-8-2E  
La Salle River @ Sanford  
La Salle River @ Elie  
Morris River @ Morris  
Plum River @ St. Jean  
Tourond Creek @ PTH 59  
Rat River @ Otterbourne  
Dead Horse Creek @ Morden  
Rosengart Drain NE 32-5-6E  
Rosengart Drain E 26-5-6E  
Rosengart Drain E of PTH 12  
Rosengart Drain S 35-5-6E

TABLE IX

Hydrometric Stations - Assiniboine River Basin

Assiniboine River

Kamsack  
Shellmouth Dam  
Roblin  
Millwood  
Russell  
St. Lazare  
Virden  
Griswold  
Brandon  
Holland  
Portage la Prairie  
Baie St. Paul  
Headingley  
Hood Bridge  
Southport  
Miniota  
Rossendale

Assiniboine River Tributaries

Qu'Appelle R.	@ Tantallon
Minnedosa R.	@ Minnedosa
Minnedosa R.	@ Rivers
Souris R.	@ Wawanesa
Sturgeon Cr.	near Grace Hospital

TABLE X

Hydrometric Stations - Red River Basin in the United States

Marsh River	@ Ada	Antelope Creek	@ Dwight
Marsh River	@ Shelley	Rush River	@ Armenia
Wild Rice River	@ Ada	Middle River	@ Argyle
Wild Rice River	@ Abercrombie	Ruffy Brook R.	@ Marvel
Wild Rice River	@ Twin Valley	Rapid River	@ Baudette
Sandhill River	@ Climax	Red Lake R.	@ Gooderich
Clearwater River	@ Red Lake Falls	Red Lake R.	@ Crookston
Clearwater River	@ Plummer	Red Lake R.	@ Red Lake
Lost River	@ Oklee	Herzog Cr.	@ Concrete
Little Pembina R.	near Walhalla	Tongue River	@ Akra
Sheyenne River	@ Kindrid	Goose River	@ Mayville
Sheyenne River	@ Cooperstown	Goose River	@ Portland
Sheyenne River	@ Lisbon	Goose River	@ Hillsboro
Sheyenne River	@ Valley City	Moose River	@ Gatzke
Sheyenne River	@ West Fargo	Thief River	@ Thief River Falls
Sprague River	@ Sprague	S. Branch Two Rivers	@ Pelon
Buffalo River	@ Dillworth	S. Branch Two Rivers	@ Lake Bronson
Buffalo River	@ Hawley	S. Branch Two Rivers	@ Hallock
Buffalo River	@ Sabln	Red River	@ Grand Forks
Buffalo River	@ Downe	Red River	@ Fargo
Wild Rice River	@ Hendrum	Red River	@ Oslo
Cart Creek	@ Mountain	Red River	@ Drayton
Cart Creek	@ Crystal	Red River	@ Wahpeton
Forest River	@ Whitman	Red River	@ Halstad
Forest River	@ Fordville	Red River	@ Pembina
Forest River	@ Minto	Roseau River	@ Roseau Lake
Park River	@ Union	Roseau River	@ Roseau
Park River	@ Grafton	Roseau River	@ Badger
Park River (N.Br.)	@ Garden	Roseau River	@ Caribou
Park River (S.Br.)	@ below Homme Dam	Roseau River	@ Ross
Park River	@ Adams	Roseau River	@ Malung
Maple River	@ Hope	Roseau River	below South Forks
Maple River	@ Mapleton		